Absolute Equation of State Measurements of Low-Z Materials at Multi-Mbar Pressures

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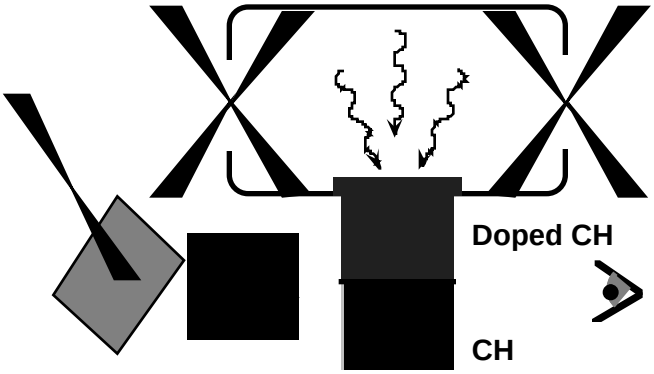
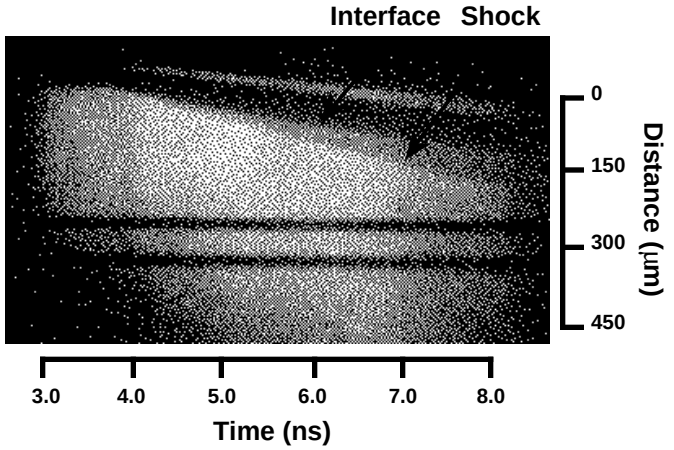
We have recently reported on the measurement of the equation of state of liquid deuterium along the principal Hugoniot up to a pressures of 2 Mbar (200 GPa)[1]. These experiments utilized a high power smoothed laser beam to directly shock the D_2 sample. In those experiments we were able to obtain absolute final pressure and density data by using temporally resolved radiography to measure both the particle speed and the shock speed in the sample. We have also used a similar arrangement to obtain absolute EOS data on low-Z solids at pressures greater than 10 Mbar. In this case the shock driver is a gold hohlraum into which 8 beams of the Nova laser are focused. The resulting x-ray field in the hohlraum drives a shock into a package consisting of a pusher, fabricated from polystyrene (CH) doped with bromine, and the sample. Figure 1 shows the arrangement for a CH sample.

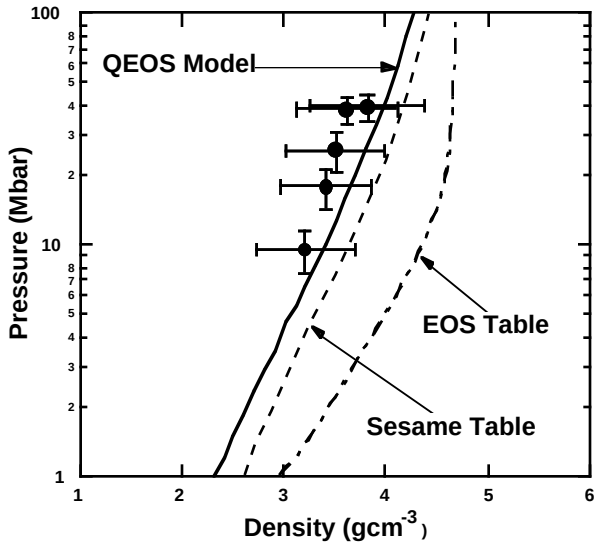


X rays for radiography are provided by the remaining two Nova beams irradiating a backlighter foil. Streaked transmission of the backlighter reveals the motion of both the pusher-sample interface and the shock front.



(The pusher is opaque to the x rays, the unshocked sample is more transparent than the higher density shocked sample.) A radiograph is shown in figure 2.

In figure 3 we show the measured polystyrene Hugoniot from 10 to 40 Mbar along with calculated values from two different EOS models[3,4] along with the Hugoniot calculated from the Sesame EOS library[5]. The QEOS model[4] and the Sesame table[5] produce Hugoniots that are in agreement with the data. However, an older model[3] does not. These results, and others, will be discussed.



These experiments demonstrate that laser-driven shocks can be used confidently and effectively for equation of state studies at pressures beyond those attainable by traditional techniques.

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References

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